Fruit Recognition and Weight Scale Estimation Based on Visual Sensing

Budi Sugandi[1)], Ria Wahyu[2)], Sindi Apriliana[3)] and Fitri Ramadani Putri[4)]
[1,2,3,4]*Politeknik Negeri Batam, Batam, Indonesia*

E-mail: budi_sugandi@polibatam.ac.id

Abstract: This paper aims to develop a system to recognize fruit and estimate its weight scale based on visual sensing. The images of fruit are captured by camera and processed by image processing to be recognized and estimated their weight. The fruit recognition is performed based on average of RGB histogram. The RGB histogram of each fruit is calculated and saved as training data. To evaluate the recognition process, the testing data is compared with training data. The weight scale estmation is performed by calculating the height dan width of the detected fruit image. The regression equation is used to determine the weight of the fruit. The experiment was performed to 8 types of fuit with 10 samples data of each. The experiment results show the effectivenes of the algorithm to recognize and estimate the weight of fuit with average error 9.38 % of recognition and 4.85% of weight estimation.

Keywords: fruit recognition, weight scale estimation, visual sensing, rgb histogram

1. Introduction

Object recognition is one of the important topic in computer or machine vision. Many applications are developed to solve the problem of recognition process. Fruit recognition is part of object recognition which plays important role in nowadays technology. However, the system still has a challenge to be improve to make it easier and user friendly with high presision, high accuracy and high speed. In addition the need of weight scale that automatically measure the weight and the price of the fruit also become demanded.

Many studies have been proposed to overcome the challenge.The fruit classification based on shape, color and texture have been proposed [1]. The proposed method used the image feature as input for artificial neural network to classify the fruit. The result show the accuracy up to 96%. Fruit recogniton is not only recognize name of the fuit but also for grading and fruit disease detection. Nikhitha, et al. focued their work to develop a user friendly application to recognize the fruit disease. Their system was implemented in Tensor flow platform. The proposed algorithm succesfully recognize the percentage of disease infection on banana, aple and cherry fruits [2]. The method of fruit recognition was also proposed using RGB-D camera for a fruit-harvesting robot applocation. The method was proposed using 3D information from RGB-D camaera dan 2D image captured by camera [3]. Bayram, et.al. propsosed the fruit recognition and classification using deep learning [4]. Their model is developed on Keras platform. The proposed system is implemented on Jetson Nano in real time application. They used 20 type of fruits in 2 different data. Deep learing is also proposed by Gill, et al. in their application. They used deep learning Convolutional Neural Network and Recurrent Neural Network in their proposed method [5]. In another approach, Alresheedi, et al, made a comparation between classical machine learning method and deep learning to recognize dates fruit [6]. The classical method is used Bayesian network, Support Vektor Machine and Multi-Layer Perceptron and for deep learning method, the Convolutional Neural Network is used. They obtain that deep learing has 2 % more accurate compare to classical method. The fruit weight estimation have been proposed also in many studies. Aung, et al. propose an algorithm to estimate the weight of the mango. They use geometric features such as area, width and length of the fruit. They obtained the accuracy of the algorithm 95 % for the estimation [7]. The similar method proposed by Kumari, et al. They proposed image segmentation to estimate the size of the fruit. They obtain 98 % accuracy [8].

The previous proposed methods only propose a fuit recogntion and weight estimation in separate system. Therefore, this article propose to combine the fruit recognition and weight estimation in one system. The system firstly perform a recognition process. After the the fruit is recognized, the system estimage the weight of the fruit. The RGB histogram is used to recognize the fruit. The matching fruit is obtained by comparing the histogram of each sample fruit with the histogram on data base. The size of the detected fruit is caluculated to be used for estimating the weihgt. Each size of fruit related to its data base. The sample fruit is then compared the size to the data base to be estimated the weight.

2. Methods

This article develop a system to recognize and estimate the weight scale of the fruit. The algorithm has two steps : recognition and weight scale estimation. In recogniton, the RGB histogram between the training data and testing data is compared. The matching fruit is recognized when the difference between training and testing data is lower than such threshold. In weight scale estimation, the weight of the fruit is estimated based on the height and widht pixel of the fruit. The following is the detail of the proposed algorithm.

The detailed of the recognition step is shown in Fig 1. The process is started by capturing the fruit image using camera. After detecting the fruit, the image is cropping and marking as an ROI. The histogram is then calculated on the ROI image as shown on Fig 2. The data is saved on data base with the name of the fruit. For the testing process, the fruit image is captured and the histogram is calucaled. System will do recogniton by calculation the mathing between the test data and database. The minimum difference will be the matching name of the fruit. The name of the fruit is then shown by the system.

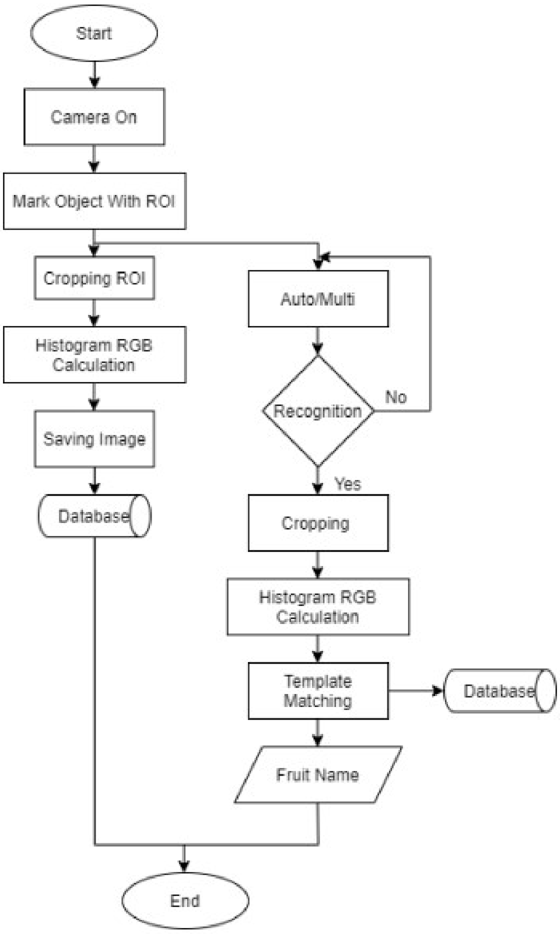

Figure 1. Fruit recognition flow chart

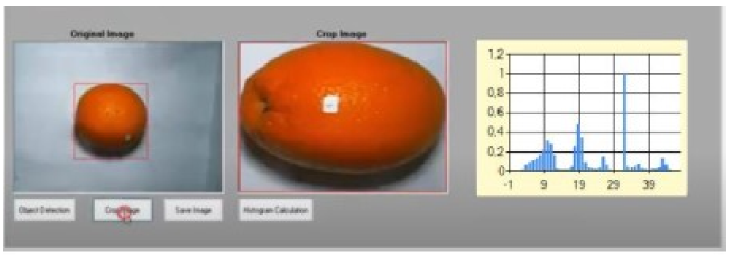

Figure 2. Sample of histogram calculation of one fruit

The weight scale estimation is performed after the fruit is recognized. The detailed process is shown on Fig 3. After the system recognizing the fruit, the pixel height and width can obtained from the object. Equation 1 show the difference between the actual size of the fruit and the pixel size.

$$real_H = pixel_H - \Delta_H$$
$$real_W = pixel_W - \Delta_W \quad (1)$$

After obtaining the $real_H$ and $real_W$, the difference between height and width is calculated using the offset. The offset value is the offset to obtain estimated value closer to the real value. This value is obtained from experiment. We obtain offset value of the fruit data is 122. Using this offset value, the difference (Δ) between real height and width is calculated based on equation 2.

$$\Delta = 122 - (real_H - real_W) \quad (2)$$

The weight estimation is then calculated using equation 3.

$$W_{est} = \Delta + (real_H - 100) - (real_H - 100)\ x\ 0.1 \quad (3)$$

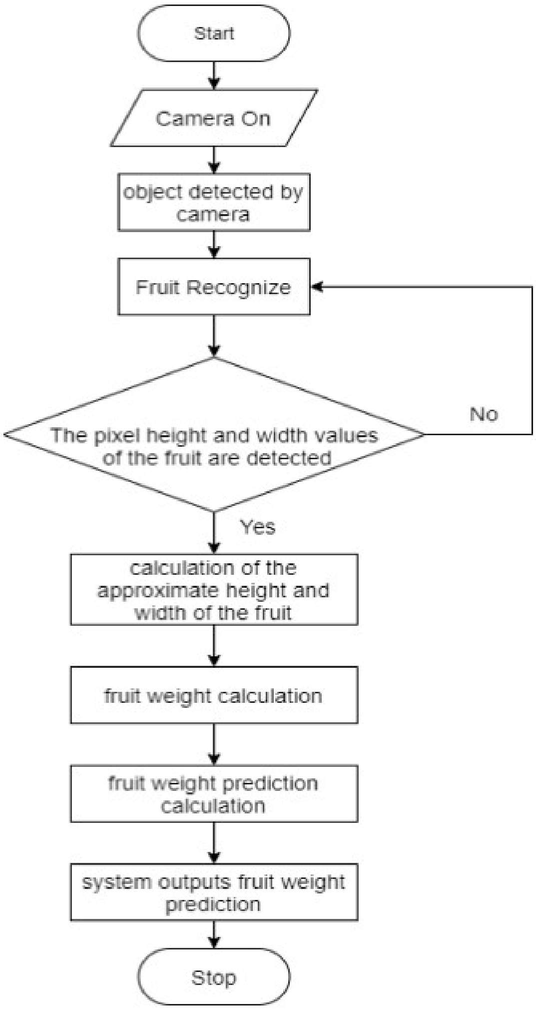

Figure 3. Flowchart of weight estimation

3. Result and Discussion

The system is implemented on the desktop application. Figure 4 show the design of GUI for the aplication. The GUI consist of four tab : *Main*, *Recognition*, *Weight Predict1* and *Weigth Predict2*. The main tab is used for displaying the result of recognition and weight estimation using auto or manual. By using auto (number 3), the fruit is automatically recognized and the weight is estimated. By using manual (number 3), we can select which category want to display (number 5). The others tab is used for training the fruit.

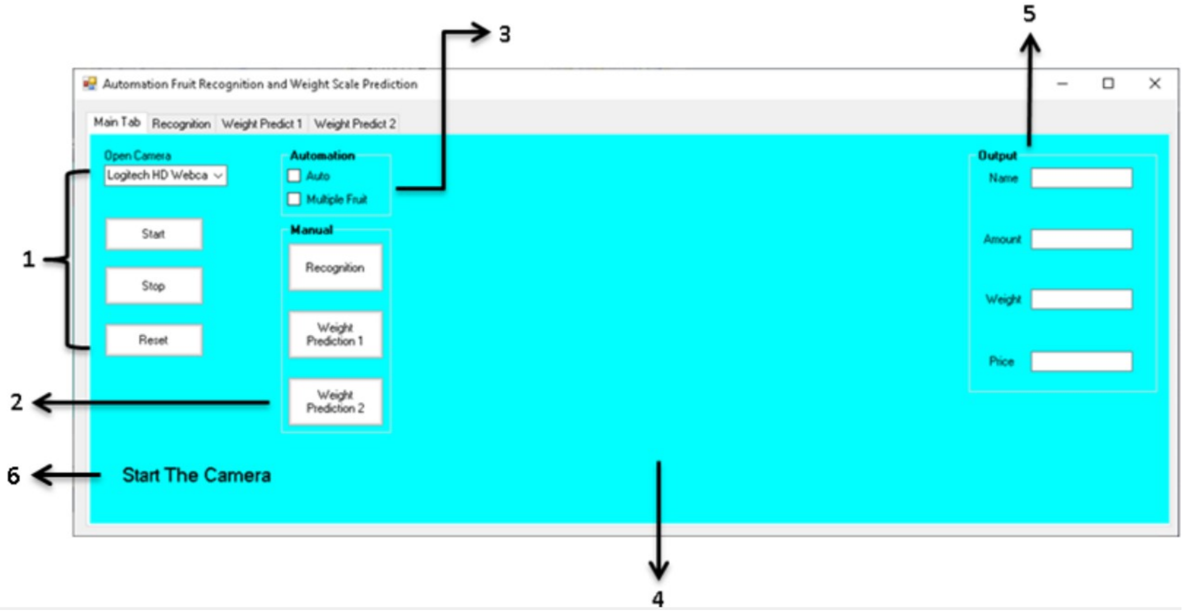

Figure 4. GUI design of the system

3.1 Fruit Recognition

Fruit recogniton is performed using 8 types of fruit with 10 samples of each. The recognition process is performed in two step: training and testing. The training process is done to obtain rgb histogram of each fruit. Each histogram is saved in data base as reference histogram. Each fruit has 10 histograms to be averaged to obtain one histogram for each fruit. Figure 5 shows the sample data of 8 type of fruit.

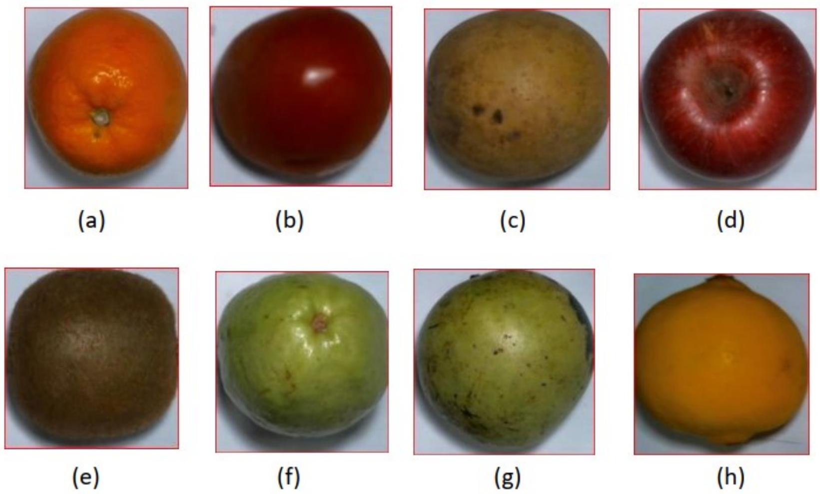

Figure 5. Sample of fruits

The recognition is performed using histogram matching which compare data from reference and test histogram. The training data of each sample is divided into R, G B value of histogram. Table 1 shows the RGB value of 8 types of fruit with 10 samples each. From the tabel, the difference value shows the different type of fruit that we can recognize the fruit using the value.

Table 1. RGB value on each fruit

Orange			Tomato			Sapodilla fruit			Appel		
R	G	B	R	G	B	R	G	B	R	G	B
1.65	3.31	0.65	2.35	1.83	0.37	3.15	6.29	2.95	4.22	7.33	2.88
1.61	3.21	0.61	2.36	1.95	0.44	2.58	5.16	2.47	3.35	6.71	3.19
1.52	3.05	0.52	2.37	1.97	0.45	2.95	5.91	2.89	4.02	7.97	3.57
1.55	3.15	0.55	2.57	2.33	0.63	2.76	5.53	2.71	3.21	5.83	2.01
1.52	3.04	0.52	2.26	2.16	0.47	2.90	5.83	2.84	4.23	7.97	3.49
1.63	2.97	0.53	2.34	2.57	0.64	3.17	6.33	3.12	3.45	6.91	3.25
1.54	3.09	0.54	2.32	2.27	0.53	2.08	4.19	1.07	4.67	8.62	3.58
1.56	3.12	0.56	2.42	2.15	0.52	2.03	4.05	0.56	3.76	7.55	3.03
1.48	2.95	0.48	2.45	2.42	0.62	2.97	5.94	2.33	3.61	6.52	2.37
1.67	3.35	0.67	2.33	2.18	0.52	2.13	4.27	1.13	2.87	4.27	1.36

Kiwi			Guava			Manggo			Lemon		
R	G	B	R	G	B	R	G	B	R	G	B
2.16	4.33	1.83	3.08	6.17	3.07	3.71	7.42	3.45	1.58	3.15	0.57
2.25	4.53	1.73	3.69	7.38	3.63	3.76	7.52	3.59	1.61	3.23	0.61
2.36	4.72	2.02	4.76	9.53	4.69	3.43	6.85	3.35	1.44	2.88	0.44
2.42	4.85	2.08	3.68	7.37	3.63	3.85	7.71	3.63	1.55	3.01	0.55
2.46	4.93	2.14	2.91	5.82	2.51	3.78	7.44	3.37	1.54	3.08	0.54
2.67	5.34	2.38	2.69	5.39	2.35	4.05	8.14	3.88	1.58	3.16	0.58
2.07	3.74	0.94	2.94	5.88	2.39	3.44	6.89	2.98	1.62	3.25	0.62
1.78	3.42	0.73	2.38	4.99	1.46	3.67	7.34	3.26	1.55	3.11	0.55
1.76	3.21	0.68	2.29	4.47	1.24	1.94	4.05	1.04	1.64	3.29	0.64
2.15	4.25	1.11	2.75	5.51	2.75	3.88	7.77	2.97	1.52	3.05	0.52

The fruit recogniton is performed using 8 types of fruit with 4 times experiment on each. The experiment is done to evaluate the accuray of the system. Table 2 shows the evaluation result. Orange, sapodilla fruit, kiwi, guava and lemon have high recognition level. However tomato has low recognition level. It may because it has similar color with apple that sometimes it failed to recognize. Figure 6 shows the recogniton result of one fruit.

Table 2. Evaluation result

Fruit Name	Succesful level (%)
Orange	100
Tomato	50
Sapodilla fruit	100
Appel	75
Kiwi	100
Guava	100
Manggo	75
Lemon	100
Average	**87.5**

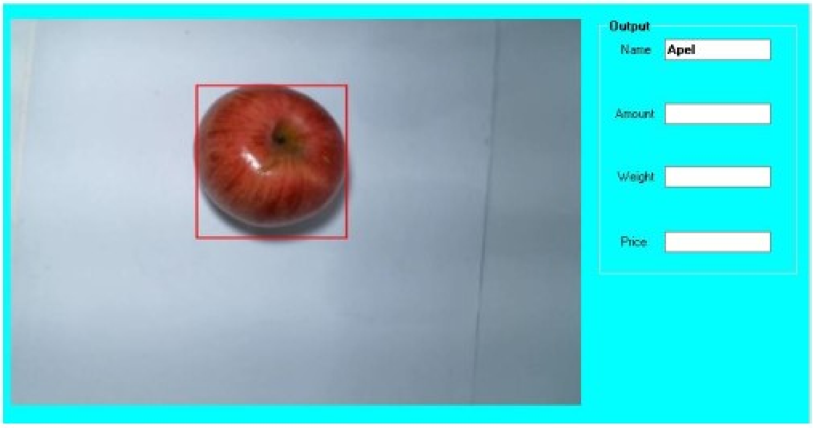

Figure 6. Recognition result

3.2 Fruit Weight Scale Estimaion

The weight scate estimation is done after the fruit recognitoin. The estimation of the weight scale is done on some sample to obtain height and width of the fruit. The height dan width is obtained from the detection of the fruit blob in the rectangle area. Table 3 shows the data of pixel height and width of each fruit on 4 times capture. We apply equation (1) and (2) to obtain the difference between real data as shown on table 4. And using equation (3) we obtain the estimated weight of each fruit as shown on table 5. The estimated error is shown on table 6. The highest estimation error is happened on estimation of the weight of manggo and the lowest on the estimation weight of orange. The estimation result is shown on fig 7.

Table 3. The pixel height and width of fruit capture by camera

Fruit Name	Pixel Height				Pixel Width			
	1	2	3	4	1	2	3	4
Orange	120.83	125.52	121.88	199.79	68.88	66.50	69.47	63.23
Tomato	93.31	92.19	102.08	86.46	54.03	51.36	57.3	55.22
Sapodilla fruit	102.08	103.13	106.25	102.08	63.83	61.45	61.75	63.83
Appel	112.5	115.11	114.58	121.35	59.38	59.67	57.89	60.27
Kiwi	95.83	91.15	96.35	94.79	55.22	54.03	53.14	53.73
Guava	147.74	152.6	153.12	151.04	92.03	94.11	94.41	79.56
Manggo	111.46	104.38	116.15	110.94	63.83	66.50	65.02	68.28
Lemon	107.73	108.85	106.25	106.25	72.73	77.19	81.64	78.38

Table 4. Difference (Δ) data of the fruit

Fruit Name	Difference (Δ) data of the fruit			
	1	2	3	4
Orange	1052.50	1045.43	1052.04	967.89
Tomato	494.17	494.62	490.67	504.21
Sapodilla fruit	812.2	808.77	805.95	812.20
Appel	897.33	895.01	893.76	889.37
Kiwi	479.84	483.33	477.24	479.39
Guava	2464.74	2461.96	2461.74	2448.97
Manggo	972.82	982.57	969.32	977.79
Lemon	725.45	728.79	735.84	732.58

Table 5. Actual and estimated weight of fruit

Fruit Name	Actual weight (gram)				Estimated weight (gram)			
	1	2	3	4	1	2	3	4
Orange	190	180	185	180	185.65	182.80	186.13	172.10
Tomato	115	110	135	105	116.45	114.09	119.04	118.52
Sapodilla fruit	145	155	155	155	157.07	154.59	154.58	157.07
Appel	155	160	155	175	161.58	161.61	159.88	161.59
Kiwi	115	105	115	110	116.09	115.37	113.96	114.7
Guava	335	340	375	340	347.71	349.30	349.55	334.91
Manggo	165	145	165	165	173.13	176.51	173.86	177.64
Lemon	155	160	150	150	156.41	160.76	165.47	162.21

Table 6. Error level of each fruit weight estimation

Fruit Name	Error (%)
Orange	2.21
Tomato	7.42
Sapodilla fruit	2.55
Appel	4.02
Kiwi	4
Guava	3.7
Manggo	9.92
Lemon	4.96
Average	4.85

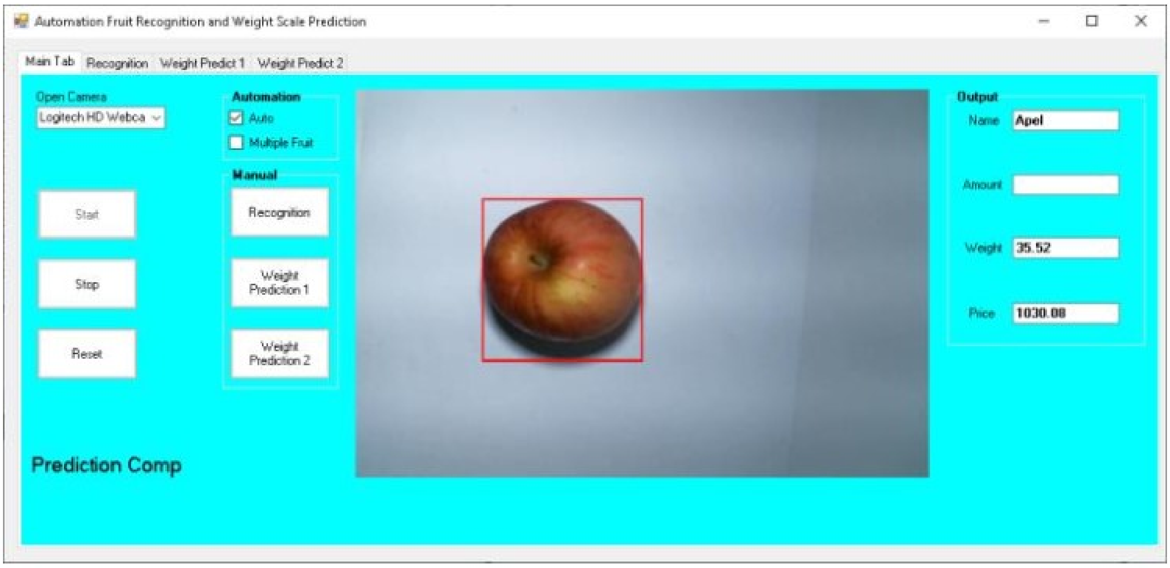

Figure 7. Estimaton result

4. Conclusions

This article have proposed a system to recognize and estimate weight scale of the fruit. The system shows the succesfully result. The system successfully recognized the fruit with accuracy 87.5%. The lowest accuracy is happened on the recognition of tomato. The system also succesfully estimated the weight of the fruit with average error 4.85%. The highest error is happened on estimated the weight of manggo and the lowest when estiamated of the weight of orange.

Improving the sytem to increase the accuracy can be performed using deep learing that has high accuracy and high speeed processing. And also by adding another camera to capture the image, the image can be detect not only in one side but also another side. This will improve estimation of weight scale. These remain works will be for near future work.

Reference

[1] B. Pratap, N. Agarwal, S. Joshi, and S. Gupta, "Development of Ann Based Efficient Fruit Recognition Technique," *Glob. J. Comput. Sci. Technol. CSoftware Data Eng.*, vol. 14, no. 5, 2014.

[2] M. Nikhitha, S. Roopa Sri, and B. Uma Maheswari, "Fruit Recognition and Grade of Disease Detection using Inception V3 Model," *Proc. 3rd Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2019*, pp. 1040–1043, 2019, doi: 10.1109/ICECA.2019.8822095.

[3] T. Yoshida, T. Kawahara, and T. Fukao, "Fruit recognition method for a harvesting robot with RGB-D cameras," *ROBOMECH J.*, vol. 9, no. 1, 2022, doi: 10.1186/s40648-022-00230-y.

[4] H. B. Unal, E. Vural, B. K. Savas, and Y. Becerikli, "Fruit Recognition and Classification with Deep Learning Support on Embedded System (fruitnet)," *Proc. - 2020 Innov. Intell. Syst. Appl. Conf. ASYU 2020*, 2020, doi: 10.1109/ASYU50717.2020.9259881.

[5] H. S. Gill, G. Murugesan, B. S. Khehra, G. S. Sajja, G. Gupta, and A. Bhatt, "Fruit recognition from images using deep learning applications," *Multimed. Tools Appl.*, vol. 81, no. 23, pp. 33269–33290, 2022, doi: 10.1007/s11042-022-12868-2.

[6] K. M. Alresheedi, S. Aladhadh, R. U. Khan, and A. M. Qamar, "Dates fruit recognition: From classical fusion to deep learning," *Comput. Syst. Sci. Eng.*, vol. 40, no. 1, pp. 151–166, 2022, doi: 10.32604/CSSE.2022.017931.

[7] W. Aung, T. T. Thu, H. Thi Dar Aye, P. P. Htun, and N. Zar Aung, "Weight Estimation of Mango from Single Visible Fruit Surface using Computer Vision," *2020 59th Annu. Conf. Soc. Instrum. Control Eng. Japan, SICE 2020*, pp. 366–371, 2020, doi: 10.23919/sice48898.2020.9240422.

[8] S. Kumari Behera Assistant Professor, S. Sangita, P. Kumar Sethy Assistant Professor, and A. Kumar Rath Professor, "Image Processing Based Detection & Size Estimation of Fruit on Mango Tree Canopies", [Online]. Available: http://www.ripublication.com